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ABSTRACT

The effect of schooling and ability on earnings is well documented. However, the existing literature does not demonstrate conclusively whether schooling and ability are complementary determinants of earnings. In particular, recent publications by John Hause and by Paul Taubman and Terence Wales reach opposite conclusions on the existence of an interaction effect. Interestingly enough the two studies make use of the same data set, the NBER-TH sample. The author reexamines and reestimates various tests for the existence of an interaction in the NBER-TH data. He concludes that despite strong theoretical considerations in support of an interaction effect there is very little statistical evidence for a significant interaction. The theoretical importance of an interaction effect is briefly discussed, followed by a discussion of the Hause and Taubman and Wales tests. Finally, various specifications of the earnings function are estimated and exact tests for an interaction are made. The effect of alternative specifications and tests on the results are compared. (Author)

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The effect of schooling and ability on earnings is well documented. However, the existing literature does not demonstrate conclusively whether schooling and ability are complementary determinants of earnings. In particular, recent publications by John Hause and by Paul Taubman and Terence Wales reach opposite conclusions on the existence of an interaction effect. Interestingly enough the two studies make use of the same data set, the NBER-TH sample.[1] In this note I reexamine and reestimate various tests for the existence of an interaction in the NBER-TH data. I conclude that despite strong theoretical considerations in support of an interaction effect there is very little statistical evidence for a significant interaction.

To begin the theoretical importance of an interaction effect is briefly discussed. It is followed by a discussion of the Hause and Taubman and Wales (hereafter, TW) tests. Finally, various specifications of the earnings function are estimated and exact tests for an interaction are made. The effect of alternative specifications and tests on the results are compared.

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[1] The NBER-TH sample is a collection of earnings, education and extensive background data for some 5,000 World War II veterans. It includes the scores of various aptitude and ability tests taken during military service. The data is described in detail in Taubman and Wales.

Schooling and ability will be said to interact in determining earnings if a given schooling investment has a larger effect on earnings for more able students. There is good theoretical reason to believe that this must be the case because a given schooling investment is more expensive for more able students. Since opportunity costs increase with ability, individuals of higher intelligence would not seek more education than the less able unless the returns were higher. The observed tendency of more able students to seek more education suggests that there are some interaction effects.[2] Of course, this observation is in no way conclusive as we could observe higher levels of schooling investments by more able students even in the absence of an interaction. It is possible that more able students have greater educational opportunities due to family wealth or socio-economic status which leads to more schooling investment despite higher cost.[3] In addition we could argue that more able students place a greater consumption value on schooling investments.[4]

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[2] In the subsample of the NBER-TH data used in the regression analysis presented below average years of schooling increases with each ability quartile as follows: 14.57, 14.91, 15.31, 16.09.

[3] The effects of socio-economic status and ability on schooling and earnings are also discussed in Wachtel. It can be assumed that access to the GI Bill tended to equalize educational opportunities for the NBER-TH respondents.

[4] Such an effect could arise if studying has some disutility and since higher ability students need to study less they place a higher consumption value on schooling.

If the consumption value of schooling and ability interact we could observe a correlation of schooling and ability in the absence of an earnings interaction.

The present study is restricted to the interaction of measured ability and amounts of formal schooling. Measured ability reflects the output of pre-test human capital investments as well as innate ability. Thus the interaction being examined could more precisely be termed the interaction between schooling and the preparedness for schooling. It is also possible that ability interacts with post-school human capital investments as well as with earnings. Both of these problems will not be troublesome with the NBER-TH data. First of all, the ability tests taken in the army precede the college education of most respondents.[5] Secondly, I examine earnings at a single point in the life cycle for respondents of approximately the same age.

At this point, I will summarize the analyses of Hause and TW. TW conclude that there is little evidence of interaction effects while Hause concludes that there is a small but significant positive interaction. Their respective studies of the NBER-TH sample treat the data differently, use different specifications[6] and make different statistical tests.

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[5] All of the respondents finished high school and 79 per cent of the sample examined attended college.

[6] Among the differences between Hause and TW are: (a) Hause uses the natural log of earnings, Taubman-Wales do not and therefore their results are biased toward the existence of an interaction; (b) Hause eliminates numerous potential outlier observations from the sample; (c) Taubman-Wales include a biography variable; (d) Taubman-Wales classify ability into percentiles so as to allow for general non-linearities while Hause used the ability measure in continuous form.

Hause estimates earnings functions within schooling classes. His published work on the NBER-TH data does not include any statistical tests for an interaction but his published data and additional results he has provided enable me to perform some tests. The first test is the x^2-test, that Hause (1973) applied to his results with another data set to test the null hypothesis that the schooling class ability coefficients are not different from their weighted mean. When this test is applied to his estimates of the ability coefficients from the NBER-TH data the value of x^2 is 10.81. This exceeds the critical value for the rejection of the null hypothesis at the 5 per cent significance level (9.49 for 4 d.f.)[7] Alternatively, we can perform a test which is equivalent to the one used by TW. That is, use a covariance analysis to see whether the sum of sums of squared residuals from within schooling class estimates of earnings functions differ from the sum of squared residuals from an overall equation with schooling class dummies. Using Hause's estimates the F-value is 2.36 for 35, 2256 degrees of freedom. The null hypothesis of no increase in explanatory power from the use of school class regressions can be rejected at the 5 per cent significance level (the critical value is 1.90). Thus both tests suggest that there is a significant interaction, although the results are not very strong.

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[7] This and the following test are based on five schooling groups; the doctors cohort is omitted. When it is included, the value of x^2 is 10.0. Since the critical value is 11.07 (for 5 d.f.), the null hypothesis cannot be rejected.

Taubman has informed me that his conclusion is based on a covariance analysis of within ability class regressions. He reports that the F-test fails to reject the null hypothesis that the pooled equation has a higher residual variance than the sum of ability class regressions. Of course, the TW results are not exactly comparable to Hause's because of differences in specification but the contradiction is apparent. The analysis of covariance on equivalent functional specifications across ability class regressions or across schooling class regressions need not yield identical results. This can happen because the effects of the other variables in the equations may differ across school groups, but not across ability groups or vice versa. A careful reading of the Hause and TW results is therefore extremely inconclusive. In fact neither performs an entirely appropriate test for interaction effects which requires reestimation of the model.

In order to examine the effect of specification differences and to compare alternative tests for an interaction I chose a standardized sample and a set of explanatory variables that shares the characteristics of both the Hause and Taubman-Wales approaches. Of the 5,086 NBER-TH respondents only 2,576 are included in the analysis, both outlier observations and respondents with atypical labor force behavior are omitted. Those excluded are business proprietors, teachers, pilots, farmers, respondents reporting poor health, respondents out of the 44-47 years old range in 1969 and with real (1958 dollar) earnings in 1969 less than $5,000 or more than $75,000. The standard group of explanatory variables

are dummies for single respondents, Catholics, Jews, respondents residing in the South and two dummies for the level of fathers' education. Six education classes are used: no college, some college, B.A., more than B.A. but no professional degree, L.L.B., and M.D.

The first specification used is similar to Hause's. The log of earnings is the dependent variable and education class dummies and a continuous ability measure are added to the standard set of explanatory variables. To test for the interaction effect the ability measure is segmented by education class. That is, schooling class dummies are multiplied by ability, and the coefficients on the resulting variables are the ability coefficients for each schooling class. This type of specification seems to be more appropriate than estimating either schooling class or ability class earnings functions as it restricts the change in results to the schooling-ability interaction and holds the effect of all other variables constant. A summary of the results is shown in Table 1. When the interaction is ignored the ability coefficient is .0327. The value of the F-test for the significance of the segmentation of ability by school class is 1.6. The value is below the critical value for 5 per cent level of significance, $F(5,2558) = 2.2$. As expected, when the level of earnings is the dependent variable there is more evidence of interaction; the calculated F is 2.1, just below the critical level for rejecting the null hypotheses of no interaction effect.

TABLE 1

Ability Coefficients by Education Class - Hause Type Model

		Ability Coefficient[a]	Schooling Coefficient[b]
E_1	No college	.0282 (.0508)	-.2466
E_2	Some college	.0171 (.0308)	-.0992
E_3	B.A.	.0271 (.0488)	.0812
E_4	More than B.A.	.0543 (.0977)	.0771
E_5	L.L.B.	.0394 (.0709)	.4196
E_6	M.D.	.0423 (.0761)	.6069

[a] In brackets below the coefficient is the coefficient multiplied by the overall standard deviation of ability. Thus in the E_1 class a one standard deviation ability difference accounts for a 5.08 per cent earnings difference

[b] These are percentage differences from the overall sample mean earnings for each education class.

The results in Table 1 are very similar to Hauses. At the higher education levels the ability coefficients are double those of the some college and B.A. levels. However, it is also clear that the overall effect of ability is small when compared to earnings differences due to schooling alone.

The above statistical test fails to reject the null hypothesis of no interaction effect. A different result is obtained if we apply the x^2 test on the differences in ability coefficients from their overall mean.[8] If the ability coefficients in Table 1 are assumed to be independent, the x^2 test can be applied to these results. The x^2 value for the test of the null hypothesis that the ability coefficients in Table 1 are equal to .0327 is 11.87. The critical value of x^2 at the 5 per cent significance level for five degrees of freedom is 11.07. So this test would reject the null hypothesis and support the existence of an interaction.

A somewhat different specification is used to reproduce the Taubman-Wales results, although the composition of the sample and the standard set of explanatory variables are unchanged. The Taubman-Wales specification uses the level of 1969 earnings and also includes

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[8] This test is not strictly applicable unless the individual coefficients are independent of one another. This is clearly not the case for the Table 1 results estimated from the same case. However, it is no more true for Hause's schooling class regressions which depend on a particular segmentation of the sample.

a set of biography dummy variables (a measure constructed by the Air Force). To allow for non-linearities, which Taubman-Wales emphasize, ability classes are used. Table 2, Panel A shows the predicted deviations from the overall mean earnings for each ability-schooling class. As there is no interaction the ability differentials are constant across rows and the schooling differentials across columns, these are shown as well. When the variables are allowed to interact the predicted deviations from sample means are as in Panel B of Table 2. The F value for addition in explained variance when interactions terms are introduced is $F(15,2543) = 1.2$. If the biography variables are excluded the value rises to 1.3, but if log of earnings is the dependent variable the corresponding F value is only .9.

Although the statistical test suggests that the interaction in the TW type specification is not significant the results do illustrate some large interaction effects. For example, the difference in mean earnings between high school graduates and those with some post-graduate study is $4,113 in Panel A. When a schooling ability interaction is allowed for, the predicted differences range from $1,620 for the lowest ability quartile to $5,740 in the highest.

In conclusion, it is hard to evade the fact that there are schooling-ability interrelationships in determining earnings, even in the highly homogeneous NBER-TH sample. The complexity of the relationship makes an unambiguous statistical test difficult. Depending on the functional specification and the statistical test chosen, we can accept or reject

TABLE 2

Predicted Deviation from Mean Earnings - TW Type Model[a]

Ability Quartile[c]	Education Class[b] E_1	E_2	E_3	E_4	E_5	E_6	All
			Panel A: No Interaction				
A_1	-4.16	-2.49	-.28	-.02	6.35	10.23	-.98
A_2	-3.62	-1.95	-.26	+.51	6.88	10.77	.45
A_3	-2.94	-1.27	+.94	1.19	7.56	11.45	+.23
A_4	-2.09	-.42	+1.79	2.04	8.41	12.30	+1.08
All	-3.17	-1.50	+.71	.96	7.33	11.22	
			Panel B: With Interaction				
A_1	-4.27	-2.75	-.03	-1.65	5.34	7.55	
A_2	-4.14	-1.92	-.08	-.09	5.17	11.28	
A_3	-3.18	-1.56	+.47	-.04	10.11	9.55	
A_4	-2.89	-1.61	1.22	2.85	7.77	13.41	

[a]Real earnings in 1969 in thousands of dollars.

[b]See Table 1 for list of education classes.

[c]From lowest to highest.

an interaction hypothesis. However, any such test is restricted by the degree of interaction already built into the specification chosen. Finally, the opposite conclusions reached by Hause and TW stem from different tests on results that are basically the same. At this point further research should concentrate on the reasons why a certain specification is preferred rather than mechanical differences among functional forms.

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